

MEMORANDUM

CH2MHILL

Bunker Hill Long-Term Water Management - Results of CH2M HILL Scoping Session

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This memorandum describes general technical approaches, potential work element priorities, and a conceptual schedule or time-line for the following areas suggested by EPA and the State for evaluation (as referenced in Mary Kay Voytilla's and Mike Thomas's February 26, 1998 memorandum):

- Bunker Hill Mine Hydrogeology
- Evaluation of Existing Piping from the Mine to the CTP
- Geotechnical Evaluation of the Reed Dump
- Upgrades to the Central Treatment Plant
- In-Mine Sludge Disposal
- In-Mine Water Treatment

Joan Stoupa, Jim Stefanoff, and Bill Hudson of CH2M HILL and John Riley of Pyrite Hydrochem developed this memorandum. As you are aware, John Riley has specific and lengthy experience with the hydrogeology and geochemistry of the Bunker Hill Mine.

Much of the information presented herein will be in outline form and can be elaborated upon in upcoming teleconferences and meetings. Some information, especially information related to the CTP and sludge management, is presented in greater detail since CH2M HILL has already evaluated certain aspects of these particular topics.

An important end product of the following discussed efforts will be a comparison and ranking of possible CTP improvements or replacements versus costs for surface water diversions, in-mine water diversions, air seals and other AMD generation mitigation measures. AMD mitigation efforts which show the largest potential for cost effectively reducing or eliminating long-term treatment expense will be preferred.



Bunker Hill Mine Hydrogeology

MAIN AREAS IDENTIFIED FOR EVALUATION

1. Each of the following areas will be evaluated. Considerable overlap between areas is needed because many of these areas are interrelated. Coordination of these efforts with the mine owner will be needed, and should begin during work scoping and continue as the work progresses. Identify highest acid mine drainage (AMD) producing areas: so as to focus efforts on reduction of AMD metal load and liquid flow rate by diverting appropriate surface water flows or other AMD formation reduction measures (plugging, flooding, etc.)
2. Reduction of flow into the mine workings and dissolved metal load out of mine: to reduce acid mine drainage (AMD) and sludge generated by subsequent treatment
3. In-mine water storage capacity: provide surge capacity during high flow season and when CTP may be down
4. Evaluate structural stability of the mine: as it relates to in-mine sludge disposal, in-mine water treatment, and implementing a mine contingency plan
5. Evaluate remaining mineral reserves in the mine: as they relate to potential water management projects

TECHNICAL APPROACHES

Perform Literature Search and Generate a Library and Brief Summaries

Purpose: To generate a working library of existing pertinent information which will be used to focus or streamline effort required for subsequent tasks.

- Perform a literature search of existing relevant technical documents which will consist of documents archived at the University of Idaho, documents known by Dale Ralston and John Riley, documents identified by TerraGraphics, and from other sources identified during the search. Copies of the documents will be made and assembled into a reference library, cataloged, and briefly summarized. The library contents and brief summaries will be made available to the work group.

Identify Highest AMD Producing Areas

Purpose: To identify the in-mine areas which significantly contribute to the hydraulic and metal loads emanating from the mine. Subsequent AMD reduction efforts can then be prioritized to most efficiently allocate AMD remedial funds.

- Highest AMD producing areas already identified through John Riley's research and documented in his thesis and dissertation; verified by Bill Hudson. Riley research data is from mid-1980s.
- Will likely want to verify Riley's mid-1980s data to ensure that AMD producing areas have not changed. Verification could include:

- Installing in-mine flumes (5 to 10) (these flow measuring devices will provide AMD flow measurement and locations for sample collection)
- Monthly sampling of flow and water quality for 1 year or more
- Some flume O&M may also be necessary especially after high storm/flow events
- Tracer studies to evaluate the hydraulic connectivity of the mine workings
- Existing rock type and mineral information to identify areas of highest pyrite mineralization (emphasis on diamond drill holes)

Reduce Water and Air Flow into the Mine Workings and into the Major AMD Producing Areas

Goal: Reduce the outflow strength and quantity of AMD requiring treatment.

- Focus on highest AMD producing areas in terms of metal load as top priority and hydraulic load as second priority since the metal load is the primary load which consumes treatment chemicals and generates sludge
- Develop a conceptual model using maps, three-dimensional models, hydrologic data, and chemistry information as available. The model should contain a water and metal balance of the AMD within and around the mine and a description of AMD production mechanisms. Draw on previous work as much as possible and validate with new measurements. This conceptual model will further the understanding of the hydrologic connection of the mine to surface features and surface and groundwater, and it will be a tool to help evaluate the potential effectiveness of the following potential surface water diversions in addition to evaluation of in-mine water storage and sludge disposal. The conceptual model will include drainage from other tunnels than the Kellogg, such as the Reed Tunnel, as well as the Crescent and Caledonia Mines.
- Evaluate Surface Water Diversions. The following were identified based on previous evaluations.
 - Milo Creek Pipeline (currently designed and to be constructed in 1998). This project will intercept the main stem of Milo Creek above the Milo Creek Dam and convey it through a pipeline to the lower grizzly near Wardner. This is being done as part of the Milo Creek flood prevention project.
 - Re-route the West Fork of Milo Creek to prevent inflow into the Guy Cave area (could include 2 to 3 cut-off walls and pipeline in the range of 2000? lineal feet). Consider the use of the Phil Sheridan diversion.
 - Deadwood Gulch Diversion (above Arizona Dump) (cutoff wall, 120 feet of lined channel, new access road)
 - Continuing filling Guy Cave area (as material becomes available, also consider contouring and revegetation). This would reduce direct infiltration from precipitation.

- South Fork Milo Creek Diversion. A temporary diversion trial was previously conducted and indicated that infiltration into the mine workings was reduced.
 - East Fork Milo Creek above South Fork Confluence. Evaluate the effectiveness of diversions further upstream than the South Fork confluence.
 - Identify other potential areas for surface water diversions
- Evaluate the Potential Effectiveness, Feasibility, and Risks of Mine Plugging Options to backfill AMD producing areas to reduce the rate of pyrite oxidation and acid generation
 - Homestake workings
 - Asher area
 - Areas of Flood-Stanly ore body between surface and 9 Level
 - Identify other potential areas for mine plugging
 - Evaluate different types of plugs if feasible locations are found
 - Evaluate risks associated with potential plug locations, such as plug failure or creation of new springs or seeps
- Evaluate the Potential Effectiveness and Feasibility of Air Seals (barriers constructed over surface or underground openings to reduce the inflow of air into the mine)
 - May be feasible in Asher cave area
 - Identify potential areas
 - Literature search to evaluate air seal effectiveness from case studies
 - Develop air seal approach and cost
 - Evaluate potential benefit from implementation
- Evaluate the Potential Effectiveness and Feasibility of In-Mine Water Diversions to Reduce the Flow of Water into Highly Mineralized Areas
 - Flood- Stanly workings
 - Sullivan workings
 - Identify others
- General Technical Approach:
 - Underground field reconnaissance (say 20 trips by 2 people)
 - Review existing maps, models, and documents
 - Feasibility evaluations of alternatives and locations (diversions and pluggings)
 - Order of magnitude cost estimates to evaluate cost/benefit of implementation

- Deliverable: FS-like document?
- Time Frame to Implement : ~ 6 to 9 months to have locations identified and equipment installed, then a year or more for data collection to evaluate effectiveness.

In-Mine Water Storage Capacity

Purpose: To develop and implement an operational plan for in-mine water storage when above-ground storage and treatment systems are off-line. The goal is to maintain as much as possible in-mine AMD storage capacity without causing discharge of mine via surface or subsurface flow to Bunker Creek or to the SFCDR.

- Draw on previous work and validate with new measurements as needed to further the understanding of the hydrologic connection of the mine to local surface and groundwater. This effort will tie-in to the mine AMD conceptual model developed in the previous task.
- Develop “Stage-Storage Curve” for Mine
 - Rough estimates may be able to be made using mine pumping rate and rate of water drop in mine
 - Better approach would be to conduct a pump test in the mine (may not be enough power. At a minimum, evaluate the feasibility and costs to conduct a pump test to increase accuracy of estimate; compare with assumed benefits of increased accuracy)
- Review Rationale For Maintaining Mine Water At Levels Designated by Unilateral Administrative Order (UAO) to the New Bunker Hill Mining Company
- Evaluate Excess Storage Capacity based on Failure Analysis of the CTP
- Approaches to Increase Storage Capacity
 - Drawdown mine water and increase treatment during low flow (summer/fall) to create storage capacity during high flow periods
 - Based on review of existing UAO, consider revisions to “buffer” between mine portal and SFCDR elevation
- Consideration will be given to in-mine storage if the mine becomes fully operational. In-mine storage of major quantities of water may be prohibited by ore reserves at depth.

Evaluate Structural Stability of the Mine (as it relates to new AMD mitigation projects such as water diversions, mine plugs, in-mine sludge disposal, in-mine water treatment, and implementing a mine contingency plan)

Purpose: Determine the structural stability to ensure both short- and long-term worker safety and project operability

- Establish areas essential to maintain for safe implementation and long-term operation
- Identify other areas that may be used in the future (in-mine treatment and disposal)

- Review MSHA inspection records from prior inspections
- Have an MSHA inspection of the mine (inter-agency agreement with EPA needed?)
- Results of evaluation used in design and construction of AMD mitigation projects and also for sludge disposal and the Mine Contingency Plan and Mine FS evaluations

Evaluate Remaining Mineral Reserves

Purpose: Develop an estimate of remaining mineral reserves to be used to assess viability of in-mine sludge disposal locations and for inclusion in the Mine Contingency Plan.

- Use existing data from BLP
- Access additional information from Bob Hopper, current mine owner

Mine Contingency Plan

Purpose: Develop a plan for taking over key aspects of running the mine in the event the current owner is unable to operate the mine

- Use Bill Hudson's work as a basis; it contains all the primary elements of what is necessary to take over the mine and maintain it
- Flush out details with maps, tables and figures
- Estimate costs to assume maintenance of the mine (labor, electricity, and materials)
- Develop implementation approach → who, what contracting mechanism, specific procedures, etc.

This task could be completed within three to nine months depending on overlap required with parallel tasks to develop required underground details.

Evaluation of Existing Piping from Mine to CTP

Purpose: To determine if the existing pipeline may be leaking, if it should be replaced, and what the replacement cost would be

- Assess current pipeline material type, age, and condition
- Conduct an in-pipe video inspection. This would require diversion of the Kellogg Tunnel discharge for a day. The discharge could possibly be routed into the lower workings or pumped into storage tanks. If pumped into storage tanks the mine pumps need to be shut off.
- Inspection of manholes and pipeline junctions

- If the pipeline video shows a sound pipe, conduct an air pressure test or potentially a hydrostatic test
- Establish general replacement costs. In-place lining of the existing pipeline is likely preferred over excavation and replacement.

This task could be completed within a one to two month time frame. The video inspection and air/hydrostatic testing should be conducted during the late summer or fall when the AMD flows are low.

See Attachment A: Bunker Hill CTP Upgrades Scoping

See Attachment B: Bunker Hill In-Mine Sludge Disposal Scoping

See Attachment C: Bunker Hill In-Mine AMD Treatment

Attachment A
Bunker Hill CTP Upgrades Scoping
(CH2M HILL memorandum dated May 27,, 1998)

Bunker Hill CTP Upgrades Scoping

PREPARED FOR: Joan Stoupa/SEA
PREPARED BY: Jim Stefanoff/SPK
DATE: May 27, 1998

Introduction

Treatment of acid mine drainage (AMD) from the Bunker Hill Mine is currently conducted using lime neutralization in which the pH of the AMD is increased to precipitate dissolved metals as metal hydroxides. This treatment plant is known as the central treatment plant (CTP) and was constructed by the Bunker Hill Company and began operation in May 1974. The plant is currently 24 years old. The life of some of the equipment is about up and some of the equipment requires modernization if the plant is to remain part of a long-term AMD management scenario.

The CTP is configured as a high density sludge process variation of the lime neutralization process, but the plant is operated in a low density sludge mode in order to meet zinc discharge requirements. The discharged sludge percent solids is typically three percent solids and an annual average of about 10,000 to 15,000 cubic yards of dewatered sludge accumulates in sludge ponds on the CIA. Operation in a high density sludge mode would increase the percent solids of the discharged sludge to about 20 percent solids and decrease the accumulation in sludge ponds to about 5,000 cubic yards per year. However, as the plant is currently configured operation in high density sludge mode results in unacceptable levels of total zinc in the effluent due to suspended solids carryover from the thickener. This was demonstrated during the 1997 high density sludge plant trial. Plant upgrades consisting of addition of post thickener filtration of the effluent could be implemented which would allow the plant to be operated in an HDS mode.

The current discharge from the CTP does not consistently meet the existing expired permit limits, even when the plant is operated in the current low density sludge mode. Periodic exceedances are primarily due to suspended solids carry over from the thickener. Findings of the 1997 high density sludge plant trial suggest that the current operation mode removes dissolved zinc to between 0.01 and 0.20 mg/L.

The State of Idaho is developing wasteload allocations (WLAs) for cadmium, lead, and zinc for the CTP discharge through the total maximum daily load (TMDL) process for the SFCDR. The EPA is the responsible NPDES permitting agency and will set any new limits for the CTP. The current allowable daily metals discharge limits are shown in Table 1. The CTP will need to be upgraded to meet the new limits since in its current configuration it does not consistently meet the existing limits. The degree of upgrade will be dependent on the degree which the limits are lowered.

Because the CTP is part of a Superfund site, and currently treats wastewater generated during a CERCLA response action, an NPDES permit is not required for the discharge.

However, it is expected that the concentrations of pollutants in the discharge would be limited consistent with what the Clean Water Act (CWA) would require, and consistent with what is required for other inactive mines in the Coeur d'Alene basin. Specifically, it is expected that the discharge will be required to meet, at a minimum, best available technology economically achievable (BAT) for mine drainage effluent limitations and the TMDL waste load allocations (WLAs). For parameters without an established WLA (e.g. arsenic, copper, etc.) the allowable concentrations in the discharge will likely be based on State water quality standards. The water quality-based target discharge concentrations for these non-TMDL parameters must be evaluated to determine if they define the level of treatment required.

TABLE 1 Current CTP NPDES Permit Discharge Requirements				
Parameter	Daily Average Limit¹		Daily Maximum Limit²	
	mg/L	lbs/day	mg/L	lbs/day
pH (pH units)	The pH must be between 6.0 and 10.0			
Total Suspended Solids	20	985	30	1,907
Total Zinc	0.73	36.2	1.48	91.3
Total Lead	0.3	14.8	0.6	37.0
Total Cadmium	0.05	2.4	0.1	6.1
Total Copper ³	0.15	7.4	0.3	18.6
Total Mercury ³	0.001	0.05	0.002	0.12
¹ The total units discharged during a month divided by the number of days the plant operated that month				
² The maximum value attained on any day in a given monitoring month				
³ Daily monitoring for Copper and Mercury not required				

Main Issues

The main issues to be evaluated to determine the upgrades needed for the CTP are modifications required to meet stricter discharge requirements in terms of metal concentrations and metal discharge loads, modifications required to produce less sludge, and modifications required to replace/upgrade worn equipment. Each of these issues is described below.

Modifications for Stricter Discharge Requirements

The new discharge requirements will be both concentration and load restrictive. Because the metal discharge load is dependent on the achievable effluent concentration multiplied by the flow rate, reductions in AMD plant hydraulic throughput will decrease the metal discharge load for a given effluent metal concentration. Efforts to be evaluated for reducing the mine water discharge flow rate need to be considered in parallel with CTP

modifications to determine which modifications most cost effectively meet the new discharge requirements.

The extent which modifications are required to meet stricter discharge limits will depend on how strict the new limits are. In the absence of knowing what the specific limits are, another approach is to evaluate what discharge limits could be expected for certain upgrades, and then to compare the incremental improvement to the incremental expense of adding, operating, and maintaining the upgrade.

A phased approach should be used to evaluate plant upgrades for obtaining lower effluent metals concentrations. The first phase should be to document the performance of the existing plant by assembling and evaluating existing information. In parallel with this, a literature review should be conducted to evaluate other existing treatment technologies, emerging technologies, and technologies capable of recovering materials for reuse/recycle.

The next phase would be to evaluate modifications or equipment additions to the existing lime neutralization process which may allow consistent attainment of the new discharge limits. By using parts of the existing plant, this approach may be more cost effective than replacement with new processes and equipment. Modifications to the existing plant which may prove to be cost effective include addition of filtration equipment to remove suspended metal from the thickener overflow, fine-tuning of the pH setpoint to maximize removal of metals as hydroxides, and addition of iron co-precipitation to further lower concentrations of dissolved metals. In addition, the effects of adding secondary treatment processes to remove even more metal from the filtered thickener overflow should be evaluated.

Modifications to Reduce Sludge Volume

Modifications which could be made to reduce sludge volume include operation of the plant in HDS mode, addition of post-thickener sludge dewatering equipment if sludge is to be hauled off-site for disposal, and changing the process entirely to one which generates less sludge.

Implementation of HDS operation is likely the best and most cost effective alternative for reducing sludge volume. Changing the process to one which produces less sludge dry mass and dewatered volume will be evaluated. There have been some recent advances in treatment technologies which do not require precipitation. These new technologies should be evaluated and compared to HDS. In addition, sulfide perception will also be evaluated.

Addition of post-thickener sludge dewatering equipment would be required if the sludge had to be trucked to a disposal facility. Equipment of this type is readily available but is costly to purchase and operate.

Modifications to Upgrade Worn/Outdated Equipment

Some of the plant equipment is nearing its useful operational life. If the plant is to be part of a long-term AMD management scenario, then several components will need to be repaired, replaced, or modernized. These include the lime makeup system, lime transfer and feed system, the aeration basin, the polymer feed system, the thickener, the sludge pumps, and the electrical and instrumentation and control system.

General Goals/Objectives

The general goals and objectives for plant upgrades are bulleted below:

- Determine the upgrade requirements and costs (capital and O&M) to meet potential stricter discharge limits
- Determine the upgrade requirements and costs (capital and O&M) to reduce sludge volumes
- Determine the upgrade requirements and costs (capital and O&M) to replace worn and outdated equipment

General Technical Approach

The technical approach for obtaining the goals and objectives is structured with respect to the phased approach described previously.

Task 1: Document Current Plant Performance

The purpose of this task is to document the current performance of the CTP. It is possible that sampling will be required to supplement existing information and to assess treatment performance for parameters that are not currently monitored under the expired permit. The existing performance will provide a baseline for comparison to other upgrades. The following is a list of expected activities:

- Assemble existing plant performance data (NPDES sample results, the 1997 CH2M HILL HDS trial report, the 1975 Bunker Hill Company Report, etc.)
- Tabulate and summarize the existing data, likely using Excel spreadsheets
- Compare the existing plant performance to expected stricter treatment requirements, and identify areas for improvement
- Document existing sludge production rates and volumes and compare to existing available sludge pond capacities
- Evaluate and summarize alternate sludge disposal options such as new sludge ponds for thickened but not mechanically dewatered sludge, and evaluate dry disposal cells for mechanically dewatered sludge

Task 2: Evaluate Best Available Treatment and Sludge Dewatering Technology

The purpose of this task is to determine if there are any emerging or available treatment technologies which may be more effective and potentially less costly than chemical precipitation and high density sludge, and any technologies which may result in recovered materials or a salable sludge. Water treatment, sludge amendment, and sludge dewatering technologies will be evaluated. Expected activities are as follows:

- Perform a literature search (internet and research article databases)
- Contact and coordinate information transfer with representatives from other mining sites where treatment issues are also being considered, such as the Berkeley Pit, Iron Mountain Mine, and others. Mining associations, such as the Northwest Mining Association, will also be contacted, along with mining related government agencies including Environment Canada.
- Develop process flow diagrams for potential options
- Perform treatability testing if needed
- Perform preliminary equipment sizing, layout, and integration in sufficient detail for preliminary cost estimation
- Develop scoping level cost estimates for capital, O&M, and present worth costs for comparison to other upgrade options

Task 3: Evaluate Post-Thickener Effluent Filtration

The purpose of this task is to determine to what extent addition of post-thickener filtration can reduce effluent metals concentrations. This task will also provide critical information into Task 6, which focuses on other technologies for reduction of sludge volume since implementation of filters would allow use of the HDS process. Expected activities are:

- Evaluate filtration options including pressure filtration and gravity filtration. It is expected that gravity media filtration may provide the most consistent and solids-free discharge. The plant used to have pressure filters but they were removed. This evaluation should consider requirements for filtering the current sludge and also HDS sludge.
- Perform preliminary equipment sizing, layout, and integration in sufficient detail for preliminary cost estimation
- Develop scoping level costs for capital, O&M, and present worth costs for comparison to other upgrade options

Task 4: Evaluate Co-Precipitation to Reduce Dissolved Metals Concentrations

Co-Precipitation consists of adding soluble iron into the precipitation reactor (aeration basin) to promote the co-precipitation of metals (zinc is the primary target) with the iron. Ferric chloride, ferrous sulfate, and other iron salts could be added. Co-precipitation works by coercing zinc to precipitate from solution either by being swept into the iron hydroxide

floc, or by adsorption of the zinc onto the surface of the floc. The result is that dissolved zinc concentrations are lower than achievable by hydroxide precipitation alone.

The potential benefit of iron co-precipitation is that the effluent zinc concentration could be reduced. If implemented new equipment would be needed, the iron chemical would need to be purchased and managed, and additional sludge would be generated. If appreciable amounts of ferric iron are added an additional reactor and precipitation step may be required to produce HDS. Enhanced aeration may also be necessary and its benefit should be evaluated. Expected activities are:

- Review the dissolved metals data collected during Task 1 to ascertain the existing soluble metal concentrations
- Review other project experience and literature information to assess the potential benefit of iron co-precipitation for Bunker Hill AMD.
- A bench-scale treatability study will likely be required to determine expected process performance. Batch tests may be sufficient, but continuous flow testing may also be required.
- Perform preliminary equipment sizing, layout, and integration in sufficient detail for preliminary cost estimation
- Develop scoping level cost estimates for capital, O&M, and present worth costs for comparison to other upgrade options

Task 5: Evaluate Secondary Treatment

Additional treatment steps could be added after filtration to polish residual metal from the filtrate. Reverse osmosis, ion exchange, adsorption processes such as carbon adsorption, or evaporation/crystallization are examples. These add-on processes would be costly to implement and operate, but have the potential to reduce discharge metal concentrations. Many of these activities will cross-link with Task 2. Expected activities are:

- Review prior projects and the literature to generate a list of potentially applicable technologies (this will be done as Task 2)
- Contact equipment vendors
- Potentially perform treatability testing on attractive options if warranted.
- Perform preliminary equipment sizing, layout, and integration in sufficient detail for preliminary cost estimation
- Develop scoping level cost estimates for capital, O&M, and present worth costs for comparison to other upgrade options

Task 6: Evaluate Costs to Replace Worn/Outdated Equipment

The purpose of this task is to identify which components of the CTP require replacement or updating, and which are justifiable based on the results and findings of Tasks 1 through 4. Expected activities follow:

- Survey the existing equipment and catalog current condition
- Compare the current equipment to that required to meet stricter discharge limits or to produce a denser sludge
- Prioritize changes based on most critical need
- Perform preliminary equipment sizing, layout, and integration in sufficient detail for preliminary cost estimation
- Develop scoping level cost estimates for capital, O&M, and present worth costs for comparison to other upgrade options

Task 7: Develop Costs for Plant Replacement

Depending on the findings of Tasks 1 through 6, it may be more cost effective for long-term treatment requirements to replace the CTP with a new plant. The purpose of this task will be to determine what type of plant is needed and what it would cost to build and operate. The following are the expected activities:

- Develop a process flow diagram for the new plant based on the results of Tasks 1 through 6
- Perform preliminary equipment sizing, layout, and integration in sufficient detail for preliminary cost estimation
- Develop scoping level cost estimates for capital, O&M, and present worth costs for comparison to other upgrade options

Schedule

Table 2 presents a preliminary schedule for each task. The total estimated task duration is seven months. The estimated start date is June 1998, and the estimated finish date is December 1998. This December 1998 finish date is predicated on completing this task in time to provide upgrade options and cost information to EPA for assistance in evaluating stricter discharge limits.

TABLE 2

Preliminary Schedule
CTP Upgrades

Task	Preliminary Schedule
Task 1: Document Current Plant Performance	Start: June 1998 Finish: June 1998
Task 2: Evaluate Post-Thickener Effluent Filtration	Start: June 1998 Finish: July 1998
Task 3: Evaluate Co-Precipitation to Reduce Dissolved Metals Concentrations	Start: June 1998 Finish: August 1998
Task 4: Evaluate Secondary Treatment	Start: July 1998 Finish: September 1998
Task 5: Evaluate Costs to replace Worn and Outdated Equipment	Start: September 1998 Finish: November 1998
Task 6: Evaluate Best Available Treatment and Sludge Dewatering Technology	Start: June 1998 Finish: July 1998
Task 7: Develop Costs for Plant Replacement	Start: October 1998 Finish: December 1998

Attachment B

**Bunker Hill In-Mine Sludge Disposal Scoping
(CH2M HILL memorandum dated May 26, 1998)**

Bunker Hill In-Mine Sludge Disposal Scoping

PREPARED FOR: Joan Stoupa/SEA
PREPARED BY: Jim Stefanoff/SPK
DATE: May 27, 1998

Introduction

Treatment of acid mine drainage (AMD) from the Bunker Hill Mine results in production of chemical precipitation sludge requiring disposal. Options for long-term sludge disposal include pumping undewatered sludge (thickener underflow) into ponds on top of the CIA as is currently done, pumping undewatered sludge into ponds located elsewhere, pumping undewatered sludge into the mine, or dewatering the sludge and hauling it to a disposal facility either on or off-site or placing it in the mine. The following discussion focuses on in-mine sludge disposal and includes identification of main issues, and presents goals and objectives, a general technical approach and a schedule.

Main Issues

The main issues to be evaluated to determine the feasibility and cost of in-mine sludge disposal are identification of feasible disposal areas, disposal capacities of feasible areas, the physical characteristics of the sludge and the sludge/mine water chemical compatibility, and development of an implementation approach. Each of these issues is described below.

Feasible Disposal Locations

Identification of feasible disposal locations is a key issue. Considerations for evaluating feasibility include available disposal capacity, potential for dissolution of the sludge by the AMD, potential for the sludge to contribute to AMD abatement, ability to route a pipeline into the location, and future mining plans. Determining available disposal volumes is important and will be challenging because of unknowns such as collapses, muck blockages, and other potential undocumented obstacles. Mine maps, if available, can be used to estimate volumes, but will not show the current conditions of the areas. Pipeline routing locations must be carefully considered because they must be kept accessible for pipeline inspection and maintenance. The future mining potential of disposal locations must also be considered.

Disposal Capacity

Currently approximately 40 million gallons (200,000 CY) of three percent solids sludge is pumped from the CTP sludge thickener each year. The volume of dry sludge solids with zero voids (impossible to obtain but provides a baseline for comparison) is about 300,000 gallons (1,400 CY). This demonstrates how sensitive the actual disposal volume is to percent solids.

The mine disposal capacity will be affected by how dense the sludge compacts within the submerged workings, how well the sludge flows into the submerged workings once discharged from the pipe (such as into lateral shafts or down angled raises), and how much of the sludge dissolves into the mine water.

Sludge Characteristics

As described above, the sludge physical characteristics will play a role in determining the conveyance of sludge into the mine and the volume of sludge which can be placed into feasible disposal areas. Important sludge characteristics include shear/viscosity relationship, particle size gradations, surface energy, waters of hydration, angle of repose when submerged, and ability to flow under varying applied pressure due to the weight of overburden sludge. Some of these properties are already fairly understood based on recent testing conducted at the CTP, but others will require testing to develop the information. Addition of amendments to the sludge to improve its disposal characteristics and chemical compatibility with mine water will also be evaluated.

Chemical Compatibility with Mine Water

Portions of the sludge will dissolve if exposed to acidic mine water. The degree and rate of dissolution will be dependent on the pH of the mine water, the alkalinity of the sludge, the composition of the sludge, the water turbulence, the flush rate of mine water through the workings, and the rate of sludge input. Precise quantification of the degree and rate of dissolution will be difficult due to the many factors involved, but determining estimates of ranges of potential dissolution is important to assess disposal capacity and impact on the chemistry of discharged mine water.

Implementability

In concept the implementation of in-mine sludge disposal is relatively straight-forward. Buy new sludge pumps for the CTP, install a pipeline from the CTP through the Kellogg Tunnel to the discharge location(s), and pump the sludge in. However, although seemingly simple, a number of technical issues need to be evaluated. These technical issues can be subdivided into three categories: sludge/slurry properties, the conveyance pipeline, and the pumping system.

The sludge/slurry properties of particle size and gradation, shear/viscosity relationship (the sludge is thixotropic), and bulk specific gravity will need to be assessed to develop an implementation approach. The sludge/slurry properties will be combined with expected sludge generation and wasting rates to size the conveyance line. The velocity in the conveyance line must be high enough to keep the sludge particles in suspension and also to shear the slurry to enhance flowability. The pipeline materials of construction, routing, and installation must also be determined. Installation options include hanging the pipeline off the ceiling of the mine tunnels, along the walls, buried in the floors, etc. The need for pipeline flushing must also be assessed. Pump selection will consider the total dynamic head of the system, sludge properties, energy efficiency, availability, and reliability. Pump installation issues include where to place the pumps, how to tie them into the plant, and electrical service and instrumentation and control requirements.

General Goals/Objectives

The general goals and objectives for evaluation of in-mine sludge disposal are bulleted below:

- Determine implementability
- Determine available storage life
- Determine the economic viability compared to other disposal options
- Determine the implementation time frame

General Technical Approach

The technical approach for obtaining the goals and objectives is structured with respect to the main issues discussed previously.

Task 1: Accumulate/Review Available In-Mine Sludge Disposal Information

The purpose of this task is to collect lessons learned from others that have experience with in-mine sludge disposal. This information will help streamline the technical approach and may help to reduce the overall level of effort. The following is a list of expected activities:

- Perform a literature search (internet and research article databases)
- Contact Bethlehem Steel (they currently dispose coal AMD sludge into mine pools)
- Contact government agencies (e.g. USGS, EPA, MSHA, Environment Canada, etc.)
- Summarize and condense information for use in subsequent tasks
- Contact Heela and Sunshine for review of landfill operations

Task 2: Identify In-Mine Disposal Locations and Capacities

The purpose of this task is to determine which areas of the mine are feasible for sludge disposal. Both flooded and non-flooded locations will be evaluated. Expected activities are:

- Solicit mine operator's interest and/or acceptance of in-mine sludge disposal
- Collect information which describes the mine workings such as mine maps, drawings, interviews with miners (such as Joe Hauser, lead smelter foreman), discussions with Bob Hopper, etc.
- Rank and prioritize identified areas using criteria such as accessibility, useable capacity, potential for dissolution, potential for AMD abatement, consistency with current mine operations, and mineral reserves
- Develop figures and maps showing the ranked locations and estimated capacities. These figures and maps will be used in subsequent tasks for developing an implementation approach and cost estimates

Task 3: Evaluate Sludge Characteristics

The disposal characteristics of the sludge would be evaluated during this task. Disposal volumes would also be evaluated. This task should include evaluation of the existing CTP sludge, high density sludge (HDS), and sludge resulting from any treatment plant modifications to meet more stringent discharge requirements. Expected activities are:

- Determine the range of expected sludge disposal volumes including seasonal variations
- Determine the expected sludge physical properties such as specific gravity, flowability, percent solids, size gradations, etc. A laboratory testing program will be required to generate some of this information.
- Evaluate the expected chemical compatibility with the mine water. This will include evaluating sludge properties such as alkalinity, net neutralization potential, composition, and pH. The 1975 Bunker Hill Company report concerning mixing CTP sludge with mine water will be reviewed. Existing mine water chemistry information will be reviewed and additional mine water sampling and analysis may be required. Bench-scale testing may also be needed including batch testing in which sludge is mixed with mine water to evaluate the degree and rate of dissolution.
- Evaluate amendments to the sludge which may improve its handling, conveyance, disposal, and chemical characteristics. Key issues will be the ability of the amendment(s) to increase storage life and reduce future production of acid and nonacid drainage, such as using amended sludge as a plugging medium.

Task 4: Develop an Implementation Approach

This task would use the information developed in the other tasks to generate an implementation approach to the level of detail needed to develop scoping cost estimates. Capital and O&M costs will be developed including a present worth estimate for comparison to other disposal options. The estimated capacities, life spans, and costs can then be compared with other disposal options. Expected activities are:

- Preparation of a preliminary implementation plan which lists and defines prioritized disposal locations developed during Task 2. This plan would describe potential sequencing if more than one disposal location is identified.
- Preliminary design of the sludge conveyance methodology, such as a pipeline for pumpable sludge, or haulage modes for unpumpable sludge.
- Preliminary design of the conveyance scheme
- Development of scoping level cost estimates including capital, O&M, and present worth costs for comparison to other disposal options

Schedule

Table 1 presents a preliminary schedule for each task. The total estimated task duration is one year, which allows interaction and exchange of information with other tasks and project activities. The estimated start date is June 1998, and the estimated finish date is June 1999.

TABLE 1
Preliminary Schedule
In-Mine Sludge Disposal

Task	Preliminary Schedule
Task 1: Accumulate/Review Available In-Mine Sludge Disposal Information	Start: June 1998 Finish: July 1998
Task 2: Identify In-Mine Disposal Locations and Capacities	Start: June 1998 Finish: September 1998
Task 3: Evaluate Sludge Characteristics	Start: June 1998 Finish: October 1998
Task 4: Develop Implementation Approach	Start: November 1998 Finish: June 1999

Attachment C
Bunker Hill In-Mine AMD Treatment
(CH2M HILL memorandum dated May 27, 1998)

Bunker Hill In-Mine AMD Treatment

PREPARED FOR: Joan Stoupa/SEA
PREPARED BY: Jim Stefanoff/SPK
DATE: May 27, 1998

Introduction

In-mine treatment of Bunker Hill AMD is being considered as an alternative to treatment in an external treatment plant. In-mine treatment has been tried off-and-on during the last year using the Keeco process, but no definitive data has been submitted to EPA to allow accurate process scrutiny.

In-mine treatment must over-come several hurdles to be as effective as external treatment. These hurdles are set primarily by the physical difficulty of operating a treatment plant or number of plants in an underground mine. Some of the more significant hurdles are described below:

Treatment of all Discharge

Currently all the mine drainage discharges from the Kellogg Tunnel. Until either surface or in-mine diversions are implemented, if ever, that can segregate flows requiring treatment from those that meet discharge requirements and can be directly discharge, all the mine drainage will need to be treated. If AMD mitigation measures are successful in significantly reducing the flow requiring treatment, then passive in-mine treatment (e.g. alkaline drains/trenches, permeable porous reactive walls) should be evaluated for all or portions of the flow. Passive treatment could potentially be combined with plugging or amended hydraulic barriers. The following discussion focuses on treatment of all the discharge if the AMD mitigation measures cannot provide opportunity for in-mine passive treatment.

Treating all the drainage within the mine can be done by either installing multiple treatment systems at strategic locations, or installing a single system at a location where all the drainages come together. Installation of multiple treatment systems is expected to be much more expensive to construct, maintain, and operate than a single system.

Constructing a single system in the Kellogg tunnel may not ensure that all the drainage is treated since some seepage enters the tunnel in multiple locations potentially downgradient from the treatment system location. The likely best location would be at the tunnel entrance, but this would not be in-mine treatment and really no different from a much more accessible downhill location.

Another challenge relating to treatment of all the discharge is the ability to treat quick increases in flow rate, which have been observed to occur within hours. Construction of in-mine flow equalization would be challenging and also difficult to access and operate.

Reliability

In-mine treatment cannot be as reliable as external treatment because of the extra logistical problem of accessing the equipment. Equipment does and will break. Unforeseen things will happen that will shut the plant(s) down. Unexpected plant shutdowns can happen during the night, on weekends, and on holidays. Unless the plants are continuously manned, and unless all replacement parts are stored at the plant, and unless all specialty subcontractors are in the mine, having to enter the mine to diagnose, fix, and restart the plant(s) will cause additional downtime. Additional downtime will require additional emergency storage. Automatic controls will be needed to divert all influent into the emergency storage, which would likely be the lower workings. All this water would then have to be pumped back up to the plant(s) for treatment.

Often time specialty contractors are required to fix or maintain equipment. Repair and maintenance costs will be significantly higher because of the logistics of performing the work underground.

Chemical Supply

Virtually all treatment processes require that chemicals of some type or replaceable media be used. The logistics required to transport and handle these materials underground will add significantly to their unit costs.

Chemical supply and feed are often critical for plant success. Significant quantities of chemicals would need to be stored in the mine to provide enough capacity in case in-mine damage occurred which temporarily prevented transport of chemical in to the plant(s).

Electrical Supply

All treatment processes will require electricity. Reliable backup power will have to be provided into the plant(s) since failure of the main supply may be difficult or slow to repair, particularly if the reason for the failure is underground.

Effectiveness

Treatment effectiveness may be reduced due to the difficulty in monitoring the in-mine plant(s). Operator training and know-how, coupled with vigilance, leads to effective treatment. Locating the plants in the mine will hamper operator access to the plants to make equipment adjustments, monitor chemical consumption, collect samples, and tweak things that must be tweaked.

Inspection

Inspection of in-mine plants for regulatory monitoring will be hampered by the access difficulty. Both engineering and regulatory related costs will be increased due to the extra time and effort required.

Cost

Construction, operation, and maintenance of an in-mine treatment system will be significantly more expensive than an external system for the reasons described previously. The only cost savings area may be that related to sludge disposal. In-mine sludge disposal

from an in-mine treatment process will face virtually all of the same challenges as in-mine disposal of externally created sludge. The only savings which may occur would result if the distribution scheme required significantly less pipe, and if the pumping costs were eliminated or reduced. If a precipitation process were used, such as the Keeco process, the sludge volumes would be significantly greater than that being produced currently, and very much greater than those produced by an HDS plant.

Benefit of In-Mine Treatment

The only practical benefit resulting from the successful implementation of an in-mine treatment process may be the reduction in sludge handling costs. However, it is likely that more sludge would be created in an in-mine treatment process compared to an external process, which would reduce the long-term viability of in-mine treatment and disposal due to the more rapid exhaustion of storage space.

Recommendation

Because of the hurdles described previously which an in-mine treatment system must overcome, further EPA and State evaluation of in-mine treatment does not appear to be presently justified given the current state of the art, which consists primarily of chemical precipitation. It is recommended that Keeco and other private entities which propose in-mine treatment schemes be given the opportunity to justify and demonstrate their proposed processes, but they should be required to perform testing in a way which will provide reliable and accurate information which can be used to make an informed evaluation of their process. It is recommended that they be required to write a work plan meeting requirements stipulated by the EPA and the State of Idaho, and that they execute the work according to the plan. This plan should include a sampling and analysis plan and a quality assurance/quality control plan. Meaningful evaluation of the technical and economic viability of any new treatment scheme, be it in-mine or out-of-mine, must be based on defensible and reproducible data.